XVII. *Cocoon Softening in some Agrotids* (Noctuae). By T. A. Chapman, M.D., F.R.S.

[Read November 5th, 1919.]

In making some further observations on the resting positions of Lepidoptera immediately after the expansion of the wings and before the resting attitude normal to the species is assumed, I met with a circumstance in connection with the emergence from the pupa of certain Agrotid Noctuae that was new to me, and has not so far as I know been reported as to that group. The species observed all pupate underground, and make a cocoon which usually contains a good deal of silk. What I saw seemed unmistakably to indicate that this silk is softened by a special secretion by the moth during emergence, so as to facilitate its breaking through.

In order to see the moths immediately after the expansion of the wings, the accident of coming across a moth just at that stage, in the breeding cage, is rather uncertain and very disappointing. It is only too often the case that one finds the moth some little time after the critical period one wished to see had passed.

To obviate this difficulty I had the pupae out of their cocoons and laid them on the bottom of the jar. Like most others, these moths emerge at a particular time of day—often, however, spread over several hours. When emergence is imminent, the pupa, which has been darkening for a few days from the brown chitinous colour to nearly black, displays the feature that I have called "Inflation." * Air is secreted into the alimentary canal, distending the abdomen, so that the segments are stretched apart, exposing the intersegmental membrane (between the movable segments) and lengthening the abdomen, making a marked change in the appearance of the pupa.

When this extension is complete, emergence takes place very soon, generally within an hour. By watching for this indication, the emergence can be observed, without unduly prolonged watching, or futile watching when no emergence is due to take place.

Whilst inflation is taking place, the pupa frequently

* Proceedings South London Entomological Society, 1902, p. 22

moves the abdominal segments, in some cases possibly to assist the abdominal contents to accommodate themselves to the expansion that is taking place. In others the pupa is throughout quiescent.

Emergence begins by the rupture of the pupa case, and the gradual emergence of the moth seems to involve strenuous exertion, and the abdomen is obviously making the same vermicular movements that a larva does when walking. When the moth has emerged a certain distance, about 8 mm. in the case of *Triphaena fimbria* and about 5 mm. with *Agrotis comes*, it becomes suddenly absolutely still, in what I may call the triangular or akimbo attitude, because the first two pairs of legs have so far left the pupa case that the femur and tibia with the body of the insect make a triangle, the tibio-femoral articulation being held away from the side of the insect; each of these four legs therefore forms a triangle, with a somewhat grotesque effect. Almost at the same time, a globule of fluid begins to appear at the mouth at the base of the labial palpi, which are completely deflexed. As the proper use of this fluid is impossible under the conditions of the observation, it gradually accumulates till a considerable drop is formed, the pupa lying on its back, so that in almost every case the drop could no longer maintain its position and rolled off, and a second one begins to form; in one or two cases a third and even a fourth drop appeared. It seemed that the surface of the moth could not be wetted by the fluid, which consequently appeared as a spherical drop, a sphere broken only, of course, at the point at which it was being added to by the mouth. Such a drop, of course, easily fell off, later or earlier, according to whether the pupa was exactly on its back or leant a little to one side.

The emergence to the angular position occupies a little over a minute. The angular position is maintained usually for something over a minute; in a specimen of *T. fimbria* it was seventy seconds, in one of *A. comes* it extended to six and a half minutes—these are about the extreme values. During this period, in normal circumstances, no doubt the fluid is soaking into and softening the front of the cocoon. At the end of the period, in my examples, the moths suddenly completed their emergence with a rush and quickly made for a position for expansion; it was obvious that all the effort for getting out of the pupa case had taken place in the first period, though the moth was still three-fourths

within it, and that all its efforts were now available for breaking through the cocoon—a labour that my examples had not to undertake. It is to be regretted that I concentrated my attention so much on the mechanical part of the process and neglected to make any chemical examination of the fluid, which must, however, have been very perfunctory. No doubt a considerable amount of the fluid might be collected, if preparations were made for doing so, the material being a good supply of pupae of, say, *T. fimbria* and *Agrotis pronuba*, which can easily be obtained in quantity.

We have long known of the cocoon-softening fluids of Saturniids and Cerurids, and I have reported a similar fluid as used by sawflies (*Trichiosoma tibiale*); there are probably other records, so that no doubt if observations were made it would prove to be a very frequent circumstance. I have not, however, been able to find any observations reported except those on Saturniids and Cerurids, and certain Lasiocampids and Limacodids mentioned by Mr. Latter. I may say that in many specimens of *Eriogaster lanestris* and *Limacodes testudo* I have reared, I have seen no indication of a softening fluid, the lid of the cocoon being broken off by pressure from within at a specially provided brittle line, and started in *Limacodes* by a sharp pupal point.

In 1868 Trouvelot, in the American Naturalist, vol. i, p. 34, recorded that the softening of the cocoon by the secretion of a fluid by the moth about to emerge was, in the case of *Telea polyphemus*, marked by a distinct pause in the movements of the moth between the breaking of the chrysalis and the rupture of the cocoon for emergence, a pause during which the softening fluid has time to act on the adhesive material of the cocoon.

In the case of *Actias luna*, Packard (American Naturalist, vol. xii, p. 379,1879), described the "cocoon-breaker," which, it would appear, was in active use by the moth from the moment of rupturing the pupa case, till the moth broke through the cocoon, no pause occurring.

Kettlewell recorded precisely similar observations in 1907 (Journal Bombay Nat. Hist. Soc., xvii, p. 541) on *Actias selene*, and on *Antheraea roylei* and *Caligula simla*.

In Mr. Latter's papers in our Transactions for 1892 and 1895, on the emergence of *D. vinula* from its cocoon, the only definite reference to this point is in 1895, p. 400, where it appears that the insect is active during the whole

process of emergence; there is no resting period, the movements being with two objects, to "compress the contents of the body and expel drops of potassium hydroxide from the mouth" and "constitute the strokes made by the labial prongs against the cocoon wall."

In looking through Mr. Latter's papers and my own on *Hybocampa milhauseri* (Entomologist, 1890, p. 91) and on *Cerura* (Entomologist, 1892, p. 302), I conclude that there really is no resting stage in *Cerura*.

In *Hybocampa* the moth is active all the time in cutting out the lid with its "sardine opener," the cutting being facilitated by the softening fluid that is guided into the track by the opener.

In *Cerura* the moth is active in smearing the fluid over the proper area of the cocoon.

There is one fact in the emergence of *Cerura*, though this is hardly relevant to the present paper, that convinces me that the moth does not produce any effect on the cocoon with the labial prongs that Mr. Latter so carefully describes and figures, and that is that the opening by which *Cerura* emerges from its cocoon is a very irregular fracture, often in several pieces, and not alike in any two instances. Were the prongs in any way cutting or disruptive implements the lid would be of regular form and uniform in all cases, as, in fact, the lid in *Hybocampa* is.

The prongs are, as Mr. Latter recognises, to keep the "shield" in position during the movements of the moth—a function that would be in danger of failing were they also used in tearing the cocoon.

The movements of the moth are, I think, entirely directed to distributing the fluid properly; any assistance they give to the expression of it is, so to speak, accidental. I have reared a good many *Cerura* in the last few years, and my observations on them quite confirm this view of the mechanics of the escape from the cocoon.

So far as I have been able to find any published notes on the subject, the only observation of a rest being taken between breaking the pupa shell and quitting the cocoon is that by Trouvelot on *Telea polyphemus*, but one supposes it must also take place in such cases as in species of *Saturnia* like *S. pyri*, *S. carpini*, etc., that have a specially prepared exit; which, indeed, also exists in such species as *Antheraea pernyi* and *A. yamamai*, although the undisturbed cocoon shows no indication of it.

The interval, then, that occurs in these Noctuids during which the moth lies absolutely inert, is rather unusual than otherwise. The triangular or akimbo attitude has not been noticed in other cases of cocoon softening.

The elbows (or knees) must press against the sides of the cocoon, and so maintain the head of the moth against the end of the cocoon, so that the fluid at once comes in contact with it. On the softening having taken place and the moth resuming its efforts to escape, these angular projections must give effective *points d'appui* for the necessary forward efforts.

I add some notes of the actual observations:

Agrotis comes, June 14, 1919, at 8 p.m. (G.M.T.). Found a pupa lying, as it happened, on its back, with the imago so far emerged that the top of the front piece of the pupa reached only to the base of the femur of the first pair of legs, the femora and tibiae of the first and second pair of legs projecting angularly, the tarsi being still covered within the pupa case, giving, from the tibio-femoral joints standing away from the pupa, a rather unusual aspect. On the face of the moth was a globule of clear fluid. In a few minutes this fell off, then a rather larger globule appeared during a few minutes; this also fell off, and the insect still lay motionless. A trace of fluid again appeared. Then, suddenly, by a few active movements the pupal case was left and a rapid rush was made, but brought to a standstill almost at once, a place suitable for expanding the wings being found; this occurred about 8.15.

A. comes spins a loose cocoon underground; it seems a reasonable hypothesis to suppose, that at the stage of emergence observed the cocoon would make some impediment to further advance, and the fluid was intended to soften the cocoon or the earth in which it laid. The fluid appeared to come from somewhere close to the bases of the labial palpi; certainly it had nothing to do with the proboscis, which still lay, as in the pupa, straight down in front, its extremity still in the pupa case; the labial palpi were also deflexed, so as to be, as in the pupa, straight down in front (*i. e.* along the venter).

Triphaena fimbria, June 15, 1919.

9.10. p.m. (G.M.T.). A pupa that was normal 20 minutes ago has the abdominal segments stretched.

10.3. Emerged to "triangular" position in about 20 seconds, is about 8 mm. out of the pupa case, pupa and moth on dorsum. Fluid at once began to appear.

10.6. Globule of fluid is about 2·5 mm. in diameter, point of origin above bases of labial palpi, which are deflexed, pointing directly backward (towards posterior extremity).

10.7. Having been quite motionless, emergence is almost suddenly completed, taking only a few seconds, the drop of fluid falls off, and the moth rushes, almost wildly at first, to find a resting-place for expansion. Naturally, of course, the fluid would have been absorbed by the cocoon, and the moth would have had a further considerable effort to get through the cocoon and any superincumbent material.

I may abbreviate several other records.

T. fimbria, June 17.

10.5.20 p.m. (G.M.T.). Breaks pupa shell.
10.6.20. Fluid appears.
10.7.0. Reaches angular position, fluid rapidly increasing.
10.8.0. Very large globule of fluid.
10.8.10. Globule falls as moth rushes out.

T. fimbria, June 18.

9.11.0 p.m. (G.M.T.). Begins emergence.
9.12.30. Fluid 1 mm. in diameter.
9.14.0. Fluid 2.5 mm. in diameter.
9.14.15. Moves forward a little and then stops.
9.15.0. Fluid drops.
9.15.30. Completes emergence.

T. fimbria, June 13.

10.28.0 p.m. Has burst pupa and protrudes about 10 mm. The moth lies quiet, with all tarsi still within pupa. A globule of fluid appears on face.
10.31.0. Moth completes emergence.

T. fimbria, June 17.

7.30 (G.M.T.). Found a pupa with abdominal segments extended.
8.12. Began to emerge, and in 80 seconds (1.20)
8.13.20, it reached angular stage and became quite quiescent, fluid exuding from base of labial palpi.
8.16.40. Globule large, moth became active and left pupa case in a few seconds.

Agrotis comes, June 25, 1919.

9.10. p.m. (G.M.T.). A pupa has abdominal segments extended.
9.50. In the course of about 30 seconds, forced itself out of the pupa about 5 mm. with tibio-femoral joints of first and second pairs of legs projecting in triangular manner, and at once a globule of fluid began to exude from mouth, the moth being absolutely quiescent, and was of some size at the end of two minutes.
9.54. The globule is about 4.5 mm. in diameter, in another half-minute, the moth became suddenly active and rapidly completed emergence, the drop falling away at 9.54.30.

A. comes, June 17.

10.20.20. p.m. (G.M.T.). Breaks pupa.
10.21.20. Reaches angular position, and fluid appearing.
10.22. Considerable globule.
10.23.50. Globule falls off.
10.24.40. Small drop of fluid.
10.25.5. Rushes out, palpi adpressed backwards, antennae beneath wings.

A. comes, June 17.

9.46.5. p.m. (G.M.T.). Breaks pupa.
9.47.5. Fluid appears.
9.47.20. Reaches resting position.
9.49.0. Rushes out.

A. comes, June 17.

9.59.50. p.m. (G.M.T.). Begins to move.
10.0.40. In angular attitude with fluid.
10.1.30. Large globule.
10.2.30. Globule falls.
10.2.50. Small globule appears.
10.3.40. Considerable globule.
10.4.20. Large globule.
10.5.10. Rushes out.

A. comes, June 18.

8.21. p.m. (G.M.T.). Pupa breaks.
8.22.10. Angular position attained and fluid begins to appear.
8.23.0. Considerable globule.
8.24.0. Large globule.
8.25.20. Globule falls off when quite 2 mm. in diameter.
8.26.30. Fresh globule forming.
8.28.20. Globule falls off when nearly 2 mm. in diameter.
8.28.50. Small fresh globule (3rd) falls off as the moth makes the usual rush. The wild rush is more impressive after the first slow laborious emergence, and then the prolonged quiescence.

I made some observations also on *Triphaena janthina*.